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NASA Institute for Space Studies

# THEMATIC MAPPER STUDIES BAND CORRELATION ANALYSIS

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Stephen G. Ungar  
Richard Kiang

April 1976



GODDARD SPACE FLIGHT CENTER

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**THEMATIC MAPPER STUDIES  
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## GISS THEMATIC MAPPER BAND CORRELATION STUDY

*Spectral data representative of Thematic Mapper candidate bands 1 and 3-7 were obtained by selecting appropriate combinations of bands from the JSC 24-Channel Multispectral Scanner, as indicated in Table 1. These data represent a rather limited, but nevertheless diversified set of crop conditions as indicated in Table 2. Of all the bands assigned, only candidate bands 4 (.74 $\mu$  - .80 $\mu$ ) and 5 (.80 $\mu$  - .91 $\mu$ ) showed consistently high inter-correlation from region to region and time to time. This extremely high correlation persisted when looking at the composite data set in a multi-temporal, multi-location domain. The GISS investigations lend positive confirmation to the hypothesis advanced by DeGasparis, Tucker and others that TM Bands 4 and 5 are redundant.*

JSC 24-Channel MSS data were used to construct simulated TM bands, as indicated in Table 1, for a series of interband correlation studies. Note that TM band 2 was not simulated since the 24-Channel MSS detector most closely corresponding to this wavelength range was malfunctioning. The data used in these studies were acquired along a flight line selected from each of the four dates (two Intensive Test Sites). These data were considered in joint investigations into spatial degradation conducted by LARS, Earth Resources Laboratory (ERL) and GISS. A breakdown of the dates and sites, indicating the number of pixels, amount of area and crop mix is given in Table 2.

Shadowing and look angle effects tend to introduce correlations into the data which are not inherent in the ground scenes. In order



# **SIMULATION OF THEMATIC MAPPER BANDS WITH JSC 24-CHANNEL MSS**

PROPOSED THEMATIC MAPPER		24 CHANNEL MSS
BAND	RANGE ( $\mu$ )	RANGE USED
1.	.45 - .52	.46 - .50
3.	.63 - .69	.64 - .68
4.	.74 - .80	.76 - .80
5.	.80 - .91	.82 - .87
6.	1.55 - 1.75	1.52 - 1.73
7.	10.4 - 12.5	{ 10.1 - 11.0 11.0 - 12.0

**TABLE 1.**

# CHARACTERISTICS OF SITES STUDIED WITH 24-CHANNEL MSS DATA

<u>DATE/SITES</u>	<u>NO. OF PIXELS</u>	<u>AREA</u>	<u>ESTIMATED CROP MIX OF TEST SITE COVERED</u>
Finney Co., KS 6-9-75 Flight Line # 1	1,544,200	19.39 sq. mi.	Wheat (24%) Alfalfa (18%) Recently Planted (40%) Summer Fallow (12%) Other (6%)
Williams Co., ND 6-22-75 Flight Line # 2	1,384,600	17.38 sq. mil	Wheat (35%) Grass/Pasture (21%) Summer Fallow (32%) Other (11%)
Finney Co., KS 7-6-75 Flight Line # 1	1,764,000	22.15 sq. mi.	Wheat (24%) Alfalfa (18%) Corn (19%) Grain Sorghum (21%) Fallow (12%) Other (6%)
Williams Co., ND 8-15-75 Flight Line # 2	1,314,600*	16.5 sq. mi.	Wheat (35%) Grass/Pasture (21%) Summer Fallow (32%) Other (11%)

\*The three segments composing this flight line are populated as follows:

Part	I	438,200 pixels
	II	438,200 pixels
	III	438,200 pixels

TABLE 2

to compensate for this, unit color-vectors were constructed for each pixel by the following formula:

$$N'_i = N_i / \sqrt{\sum_{j=1}^4 N_j^2}$$

where  $N'_i$  is the *normalized* count in the  $i$ th band.

Correlation studies were conducted using both the raw and normalized (albedo compensated) data. Figures 1 through 4 represent results on a site by site and date by date basis. Note that except for cases of extremely high correlation the unit-vector representation tends to lower interband correlation (and strengthen anti-correlation) by removing some of the systematic variation in apparent albedo due to causes other than changes in ground reflectance (e.g., look angle effects, variation in instrument voltages). The albedo compensated correlations are more indicative of band redundancy than the uncompensated correlations.

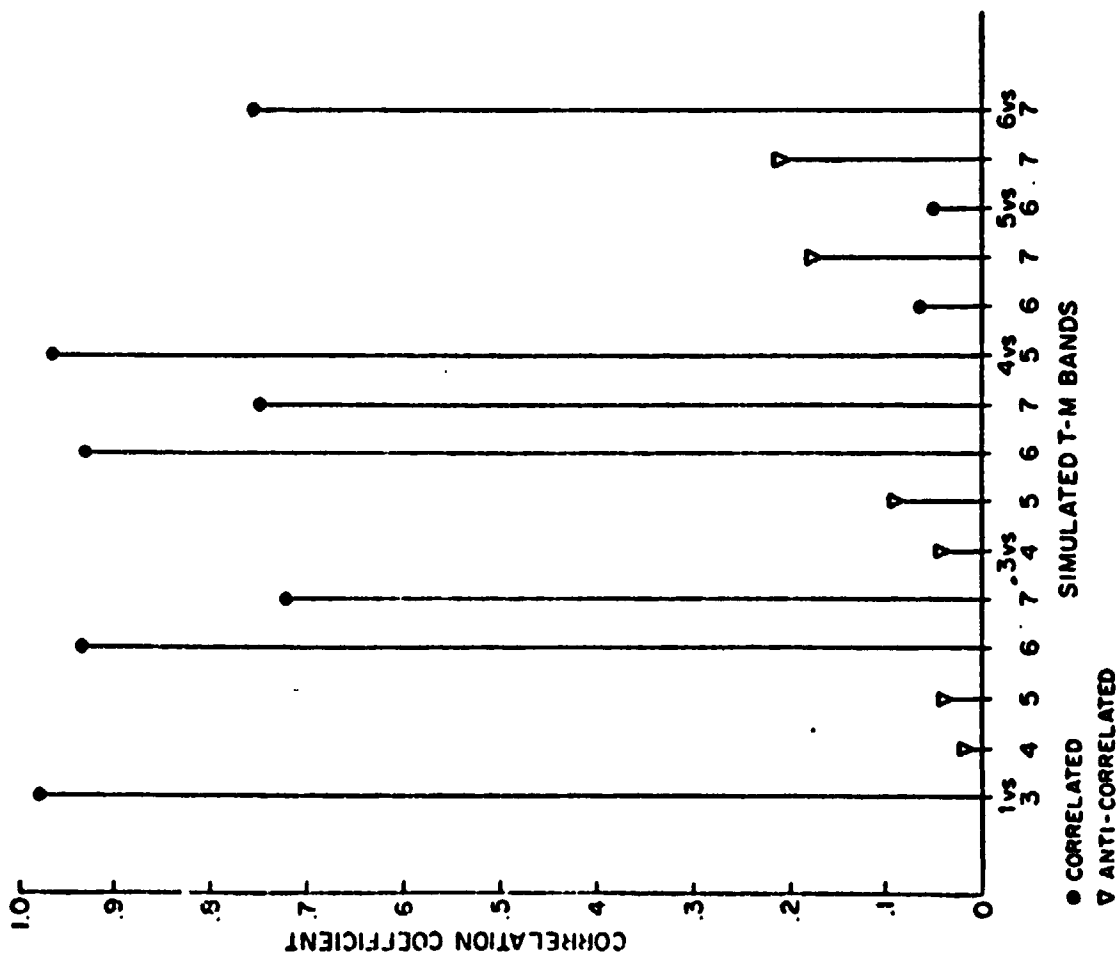
The correlation coefficient in these figures was derived in the customary manner assuming linear interband relations:

$$r_{ij} = \frac{n \sum_{k=1}^n N_i^k N_j^k - \sum_{k=1}^n N_i^k \sum_{k=1}^n N_j^k}{\sqrt{n \sum_{k=1}^n \{(N_i^k)^2\} - \left\{ \sum_{k=1}^n N_i^k \right\}^2}} \sqrt{n \sum_{k=1}^n \{(N_j^k)^2\} - \left\{ \sum_{k=1}^n N_j^k \right\}^2}$$

In order to examine the statistical validity of the derived correlation coefficients, each line was divided into several segments of approximately equal length. Individual segment results are presented for the August 15, Williams County flight line in Figure 5. The relative interband correlations remain completely consistent from segment to segment. This spatial consistency of

# FINNEY COUNTY, KANSAS - FLIGHT LINE #1 - 6/9/75

UNCOMPENSATED



ALBEDO COMPENSATED

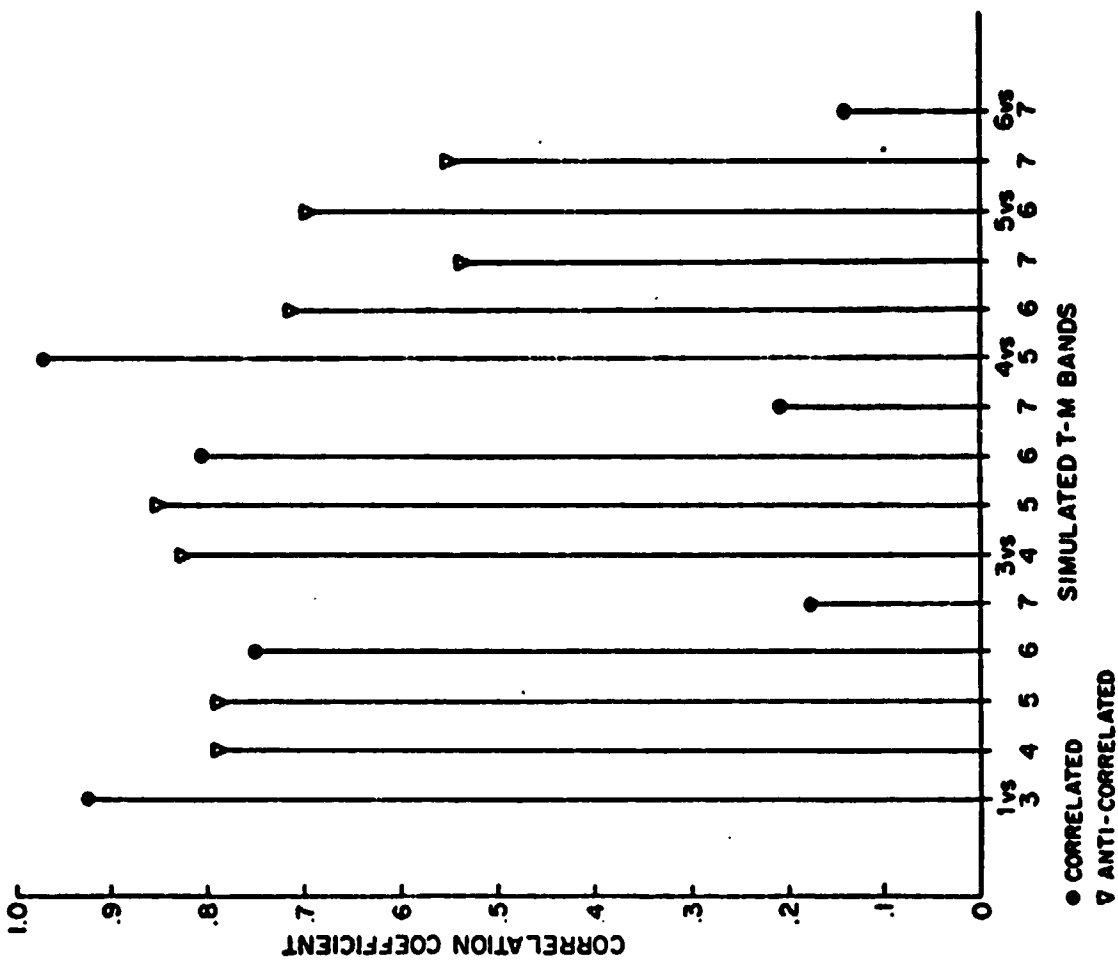


Figure 1

# WILLIAMS COUNTY, NORTH DAKOTA - FLIGHT LINE #2-6/22/75

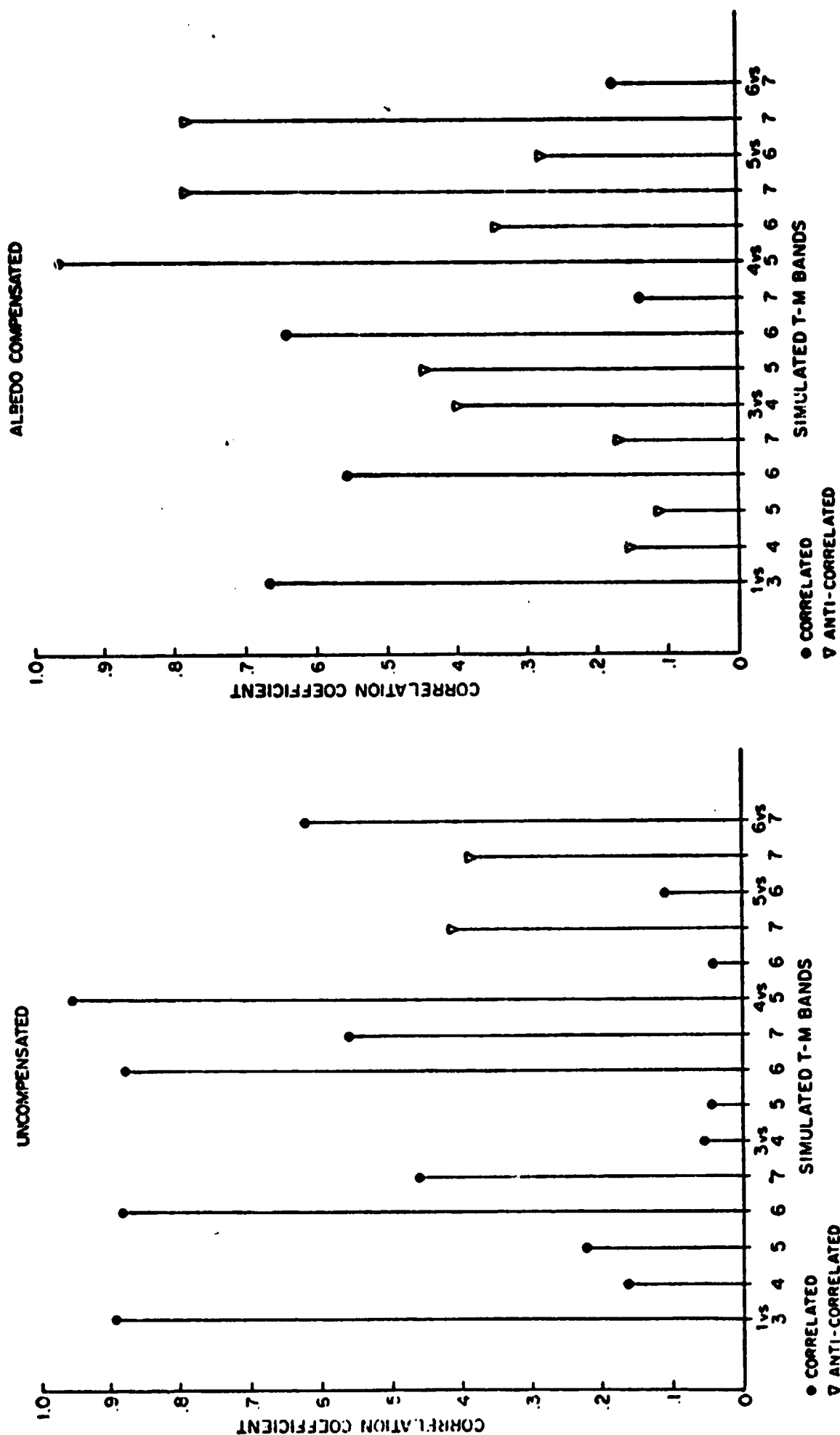


Figure 2

# FINNEY COUNTY, KANSAS - FLIGHT LINE #1 - 7/6/73

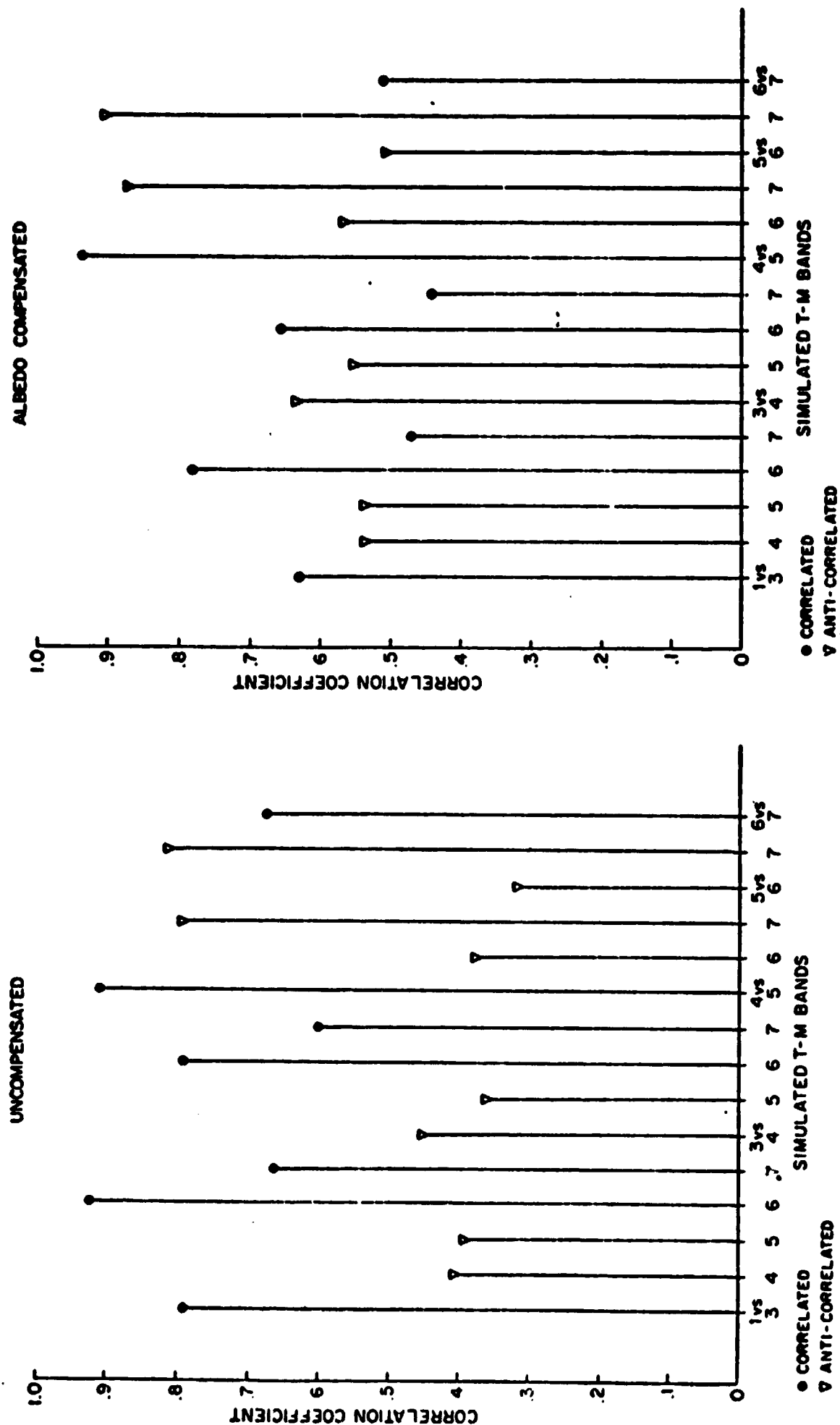
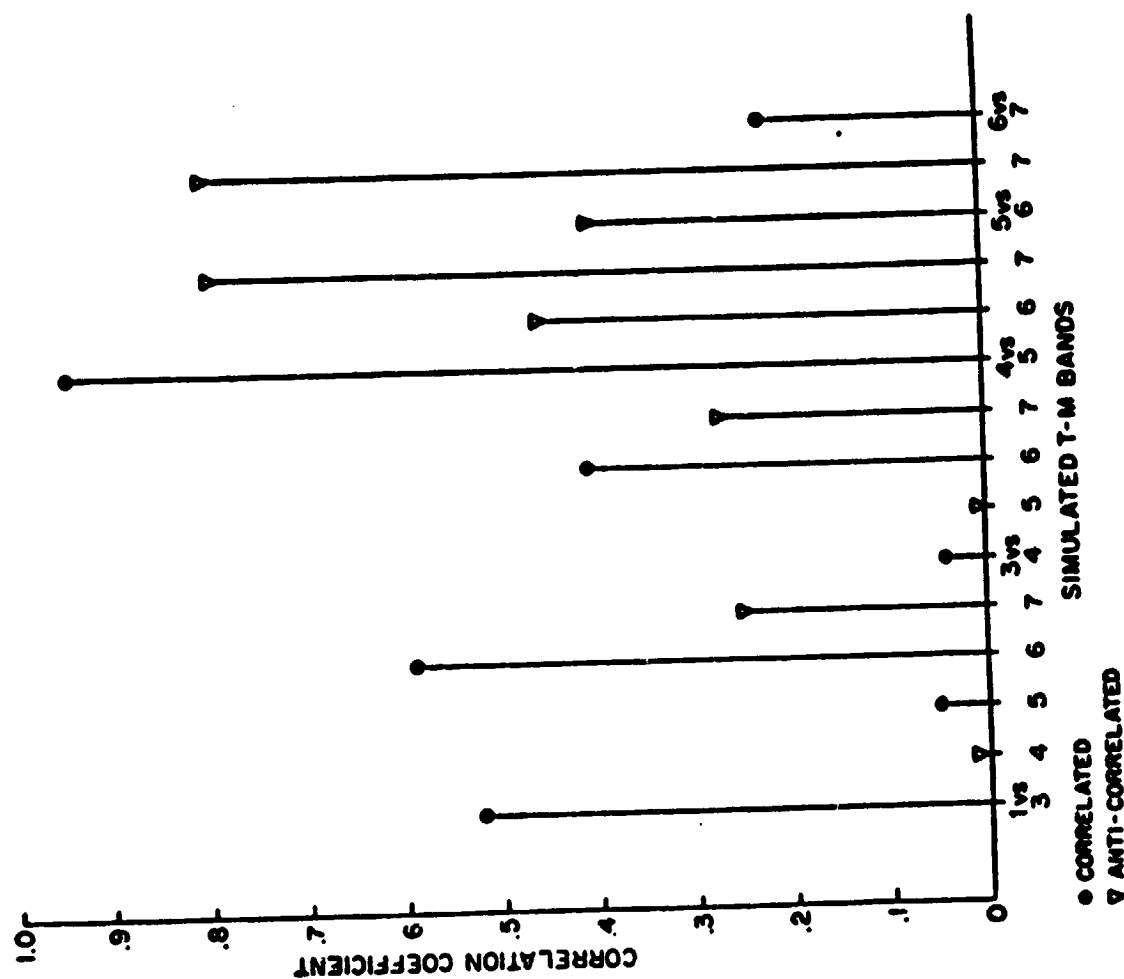


Figure 3

# WILLIAMS COUNTY, NORTH DAKOTA - FLIGHT LINE #2-8/15/73

ALBEDO COMPENSATED



UNCOMPENSATED

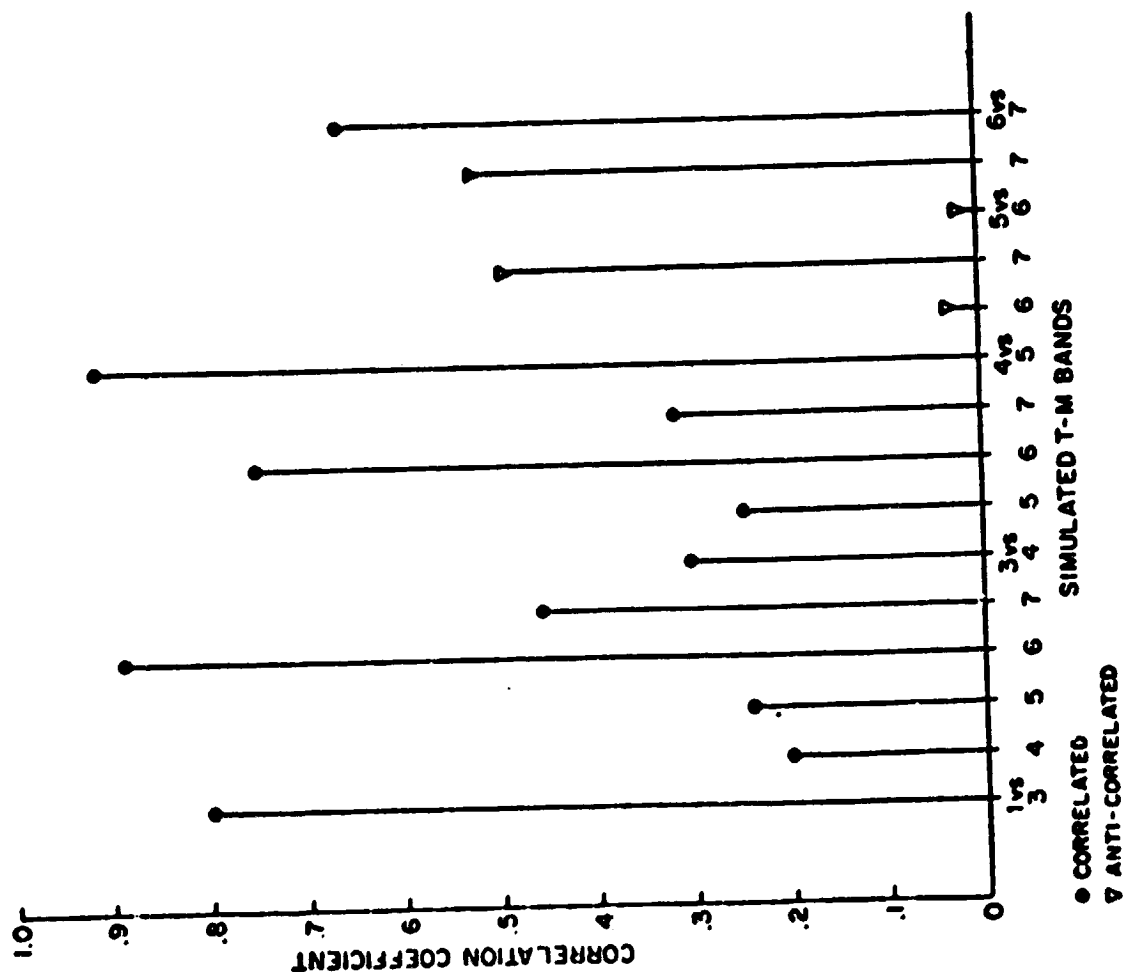


Figure 4

WILLIAMS COUNTY, N.D. - FLIGHT LINE #2 - 8/15/75

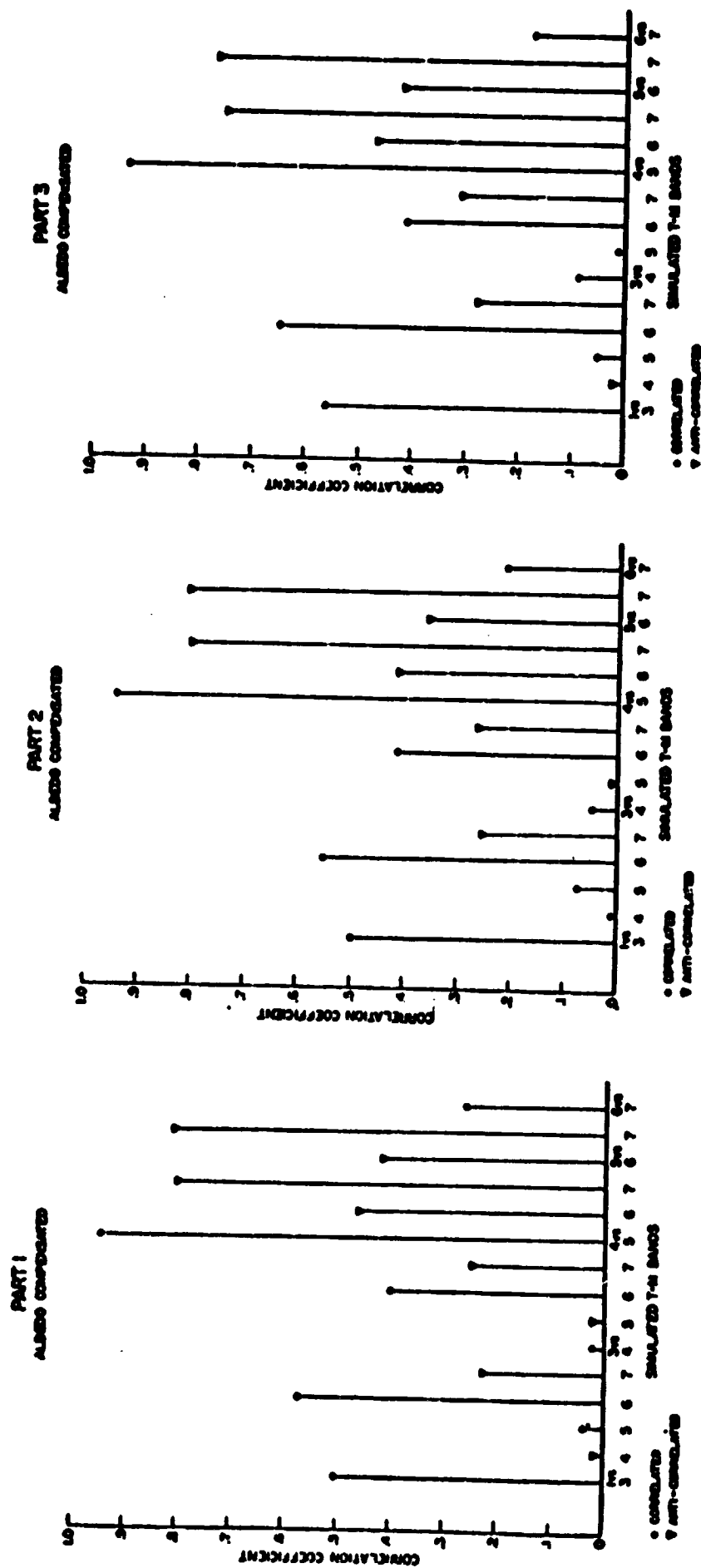


Figure 5



results was also present among the four segments of the July, Finney County flight line. However, the June 9, Finney County flight line and the June 22, Williams County flight line each displayed one anomalous segment. In both instances the segments contained appreciable cloud cover as compared to the uniformly cloud free condition for all other areas considered in this study.

The effect of cloud cover and shadow on interband correlation will be the subject of a future report.

Figure 6 represents the multi-geographic, multi-temporal data set formed by the union of all 4 data sets in the study. This data set is composed of some six million pixels representing crops such as spring and winter wheat, corn, grain sorghum, alfalfa and pasture at up to five stages of maturity.

#### Conclusions:

Arguments appearing in a GSFC report dated December, 1975 issued by J. Harnage through ERPO conclude that Thematic Mapper Bands 4 and 5 are highly redundant. These findings are based on laboratory and field spectra obtained under a highly restrictive set of conditions. Although these arguments are convincing when taken in context, they constitute a hypothesis when extrapolated to a multi-spectral scanner such as Thematic Mapper. Investigations by GISS using real MSS data under a variety of conditions may be considered an independent test of this hypothesis. Although the MSS data used represent a rather limited mix of cropping practices, the agricultural situations represented are precisely the

# ALL DATA SETS COMBINED

ALBEDO COMPENSATED

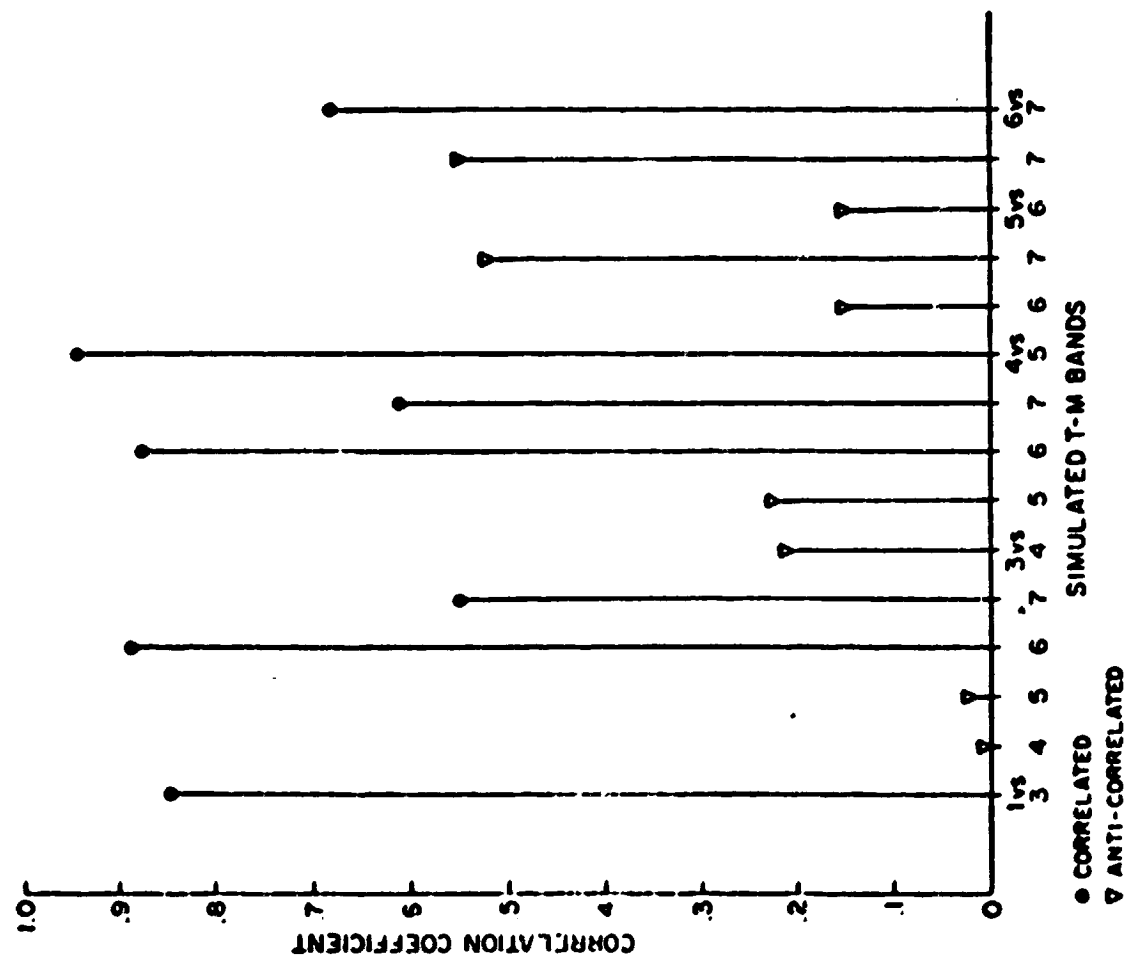
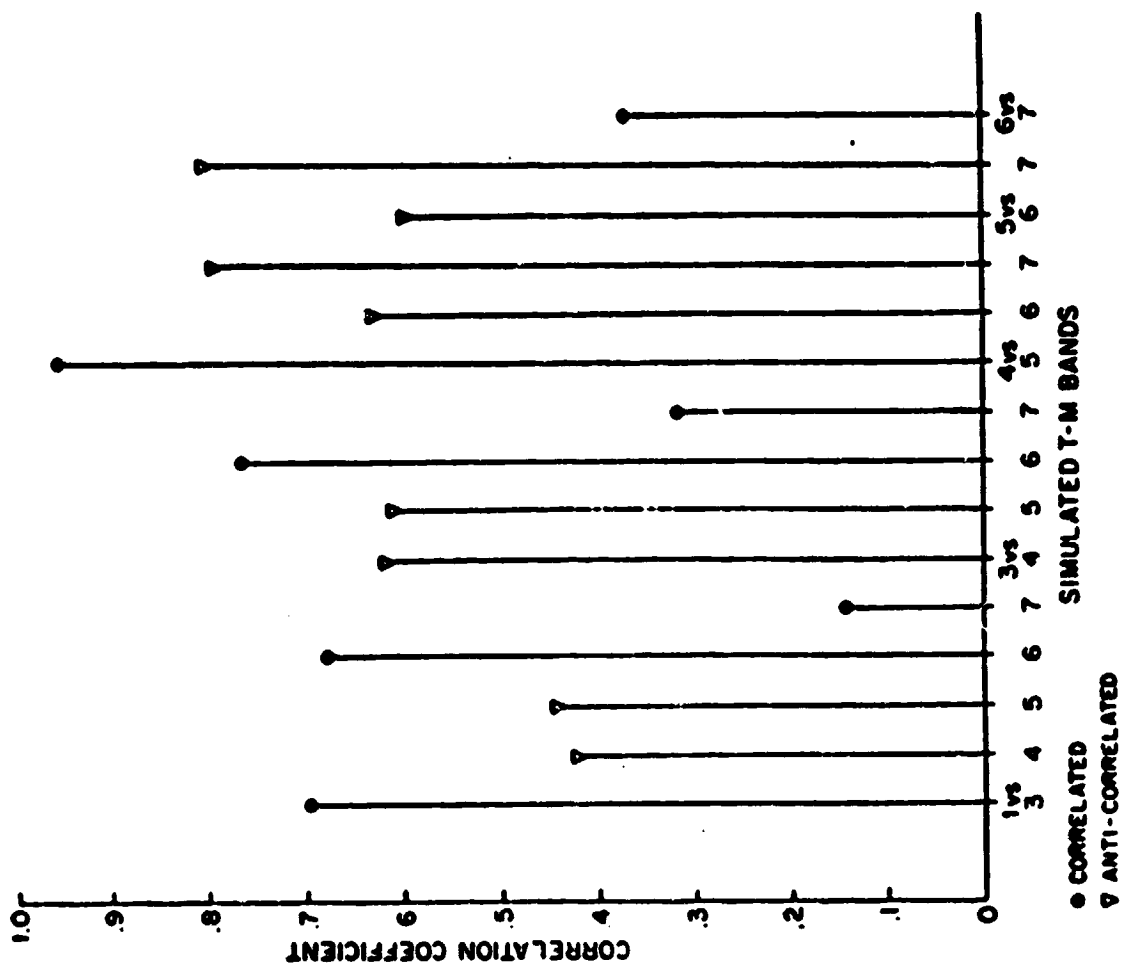


Figure 6

ones which have been heavily emphasized for consideration of Thematic Mapper design. The GISS findings are significant, and supportive of the contention that TM Bands 4 and 5 are highly redundant.

## **Appendix**

### **Linear Correlation Coefficients 24 Channel MSS Data**

















[illegible]

TABLE A4: WILLIAMS COUNTY, NORTH DAKOTA. AUGUST 15, 1975. FLIGHT LINE #2. LINEAR CORRELATION COEFFICIENTS, UNCOMPENSATED DATA. COMPARE WITH FIGURE 4 IN TEXT.

TM CHAN	MSS CHAN
1	3
3	6
4	8
5	9
6	12
7	20 & 21







TABLE A5 (PART TWO): WILLIAMS COUNTY, NORTH DAKOTA. AUGUST 15,  
1975. FLIGHT LINE #2, PART TWO. LINEAR CORRELATION COEFFICIENT,

ALBEDO COMPENSATED DATA.

COMPARE WITH FIGURE 5 IN TEXT.

TM CHAN	MSS CHAN	
1	3	20 & 21
3	6	12
4	8	11
5	9	10
6	12	13
7	20 & 21	14





[illegible][illegible]

TABLE A6: ALL SITES COMBINED. JUNE 9, JUNE 22, JULY 6, AUGUST 15, 1975. LINEAR CORRELATION COEFFICIENTS, UNCOMPENSATED DATA. COMPARE WITH FIGURE 6 IN TEXT.

TM CHAN	MSS CHAN
1	3
3	6
4	8
5	9
6	12
7	20 & 21



TM CHAN	MSS CHAN	1	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63	66	69	72	75	78	81	84	87	90	93	96	99	102	105	108	111	114	117	120	123	126	129	132	135	138	141	144	147	150	153	156	159	162	165	168	171	174	177	180	183	186	189	192	195	198	201	204	207	210	213	216	219	222	225	228	231	234	237	240	243	246	249	252	255	258	261	264	267	270	273	276	279	282	285	288	291	294	297	300	303	306	309	312	315	318	321	324	327	330	333	336	339	342	345	348	351	354	357	360	363	366	369	372	375	378	381	384	387	390	393	396	399	402	405	408	411	414	417	420	423	426	429	432	435	438	441	444	447	450	453	456	459	462	465	468	471	474	477	480	483	486	489	492	495	498	501	504	507	510	513	516	519	522	525	528	531	534	537	540	543	546	549	552	555	558	561	564	567	570	573	576	579	582	585	588	591	594	597	600	603	606	609	612	615	618	621	624	627	630	633	636	639	642	645	648	651	654	657	660	663	666	669	672	675	678	681	684	687	690	693	696	699	702	705	708	711	714	717	720	723	726	729	732	735	738	741	744	747	750	753	756	759	762	765	768	771	774	777	780	783	786	789	792	795	798	801	804	807	810	813	816	819	822	825	828	831	834	837	840	843	846	849	852	855	858	861	864	867	870	873	876	879	882	885	888	891	894	897	900	903	906	909	912	915	918	921	924	927	930	933	936	939	942	945	948	951	954	957	960	963	966	969	972	975	978	981	984	987	990	993	996	999	1002	1005	1008	1011	1014	1017	1020	1023	1026	1029	1032	1035	1038	1041	1044	1047	1050	1053	1056	1059	1062	1065	1068	1071	1074	1077	1080	1083	1086	1089	1092	1095	1098	1101	1104	1107	1110	1113	1116	1119	1122	1125	1128	1131	1134	1137	1140	1143	1146	1149	1152	1155	1158	1161	1164	1167	1170	1173	1176	1179	1182	1185	1188	1191	1194	1197	1200	1203	1206	1209	1212	1215	1218	1221	1224	1227	1230	1233	1236	1239	1242	1245	1248	1251	1254	1257	1260	1263	1266	1269	1272	1275	1278	1281	1284	1287	1290	1293	1296	1299	1302	1305	1308	1311	1314	1317	1320	1323	1326	1329	1332	1335	1338	1341	1344	1347	1350	1353	1356	1359	1362	1365	1368	1371	1374	1377	1380	1383	1386	1389	1392	1395	1398	1401	1404	1407	1410	1413	1416	1419	1422	1425	1428	1431	1434	1437	1440	1443	1446	1449	1452	1455	1458	1461	1464	1467	1470	1473	1476	1479	1482	1485	1488	1491	1494	1497	1500	1503	1506	1509	1512	1515	1518	1521	1524	1527	1530	1533	1536	1539	1542	1545	1548	1551	1554	1557	1560	1563	1566	1569	1572	1575	1578	1581	1584	1587	1590	1593	1596	1599	1602	1605	1608	1611	1614	1617	1620	1623	1626	1629	1632	1635	1638	1641	1644	1647	1650	1653	1656	1659	1662	1665	1668	1671	1674	1677	1680	1683	1686	1689	1692	1695	1698	1701	1704	1707	1710	1713	1716	1719	1722	1725	1728	1731	1734	1737	1740	1743	1746	1749	1752	1755	1758	1761	1764	1767	1770	1773	1776	1779	1782	1785	1788	1791	1794	1797	1800	1803	1806	1809	1812	1815	1818	1821	1824	1827	1830	1833	1836	1839	1842	1845	1848	1851	1854	1857	1860	1863	1866	1869	1872	1875	1878	1881	1884	1887	1890	1893	1896	1899	1902	1905	1908	1911	1914	1917	1920	1923	1926	1929	1932	1935	1938	1941	1944	1947	1950	1953	1956	1959	1962	1965	1968	1971	1974	1977	1980	1983	1986	1989	1992	1995	1998	2001	2004	2007	2010	2013	2016	2019	2022	2025	2028	2031	2034	2037	2040	2043	2046	2049	2052	2055	2058	2061	2064	2067	2070	2073	2076	2079	2082	2085	2088	2091	2094	2097	2100	2103	2106	2109	2112	2115	2118	2121	2124	2127	2130	2133	2136	2139	2142	2145	2148	2151	2154	2157	2160	2163	2166	2169	2172	2175	2178	2181	2184	2187	2190	2193	2196	2199	2202	2205	2208	2211	2214	2217	2220	2223	2226	2229	2232	2235	2238	2241	2244	2247	2250	2253	2256	2259	2262	2265	2268	2271	2274	2277	2280	2283	2286	2289	2292	2295	2298	2301	2304	2307	2310	2313	2316	2319	2322	2325	2328	2331	2334	2337	2340	2343	2346	2349	2352	2355	2358	2361	2364	2367	2370	2373	2376	2379	2382	2385	2388	2391	2394	2397	2400	2403	2406	2409	2412	2415	2418	2421	2424	2427	2430	2433	2436	2439	2442	2445	2448	2451	2454	2457	2460	2463	2466	2469	2472	2475	2478	2481	2484	2487	2490	2493	2496	2499	2502	2505	2508	2511	2514	2517	2520	2523	2526	2529	2532	2535	2538	2541	2544	2547	2550	2553	2556	2559	2562	2565	2568	2571	2574	2577	2580	2583	2586	2589	2592	2595	2598	2601	2604	2607	2610	2613	2616	2619	2622	2625	2628	2631	2634	2637	2640	2643	2646	2649	2652	2655	2658	2661	2664	2667	2670	2673	2676	2679	2682	2685	2688	2691	2694	2697	2700	2703	2706	2709	2712	2715	2718	2721	2724	2727	2730	2733	2736	2739	2742	2745	2748	2751	2754	2757	2760	2763	2766	2769	2772	2775	2778	2781	2784	2787	2790	2793	2796	2799	2802	2805	2808	2811	2814	2817	2820	2823	2826	2829	2832	2835	2838	2841	2844	2847	2850	2853	2856	2859	2862	2865	2868	2871	2874	2877	2880	2883	2886	2889	2892	2895	2898	2901	2904	2907	2910	2913	2916	2919	2922	2925	2928	2931	2934	2937	2940	2943	2946	2949	2952	2955	2958	2961	2964	2967	2970	2973	2976	2979	2982	2985	2988	2991	2994	2997	3000	3003	3006	3009	3012	3015	3018	3021	3024	3027	3030	3033	3036	3039	3042	3045	3048	3051	3054	3057	3060	3063	3066	3069	3072	3075	3078	3081	3084	3087	3090	3093	3096	3099	3102	3105	3108	3111	3114	3117	3120	3123	3126	3129	3132	3135	3138	3141	3144	3147	3150	3153	3156	3159	3162	3165	3168	3171	3174	3177	3180	3183	3186	3189	3192	3195	3198	3201	3204	3207	3210	3213	3216	32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